

Report to Rocky Mountain National Park

I. Inventory and Monitoring Project:
Amphibians and Reptiles
in cooperation with DOI
Amphibian Research and Monitoring Initiative

Final Report
30 September 2003



Erin Muths, USGS-Biological Resources Division
Fort Collins Science Center, 2150 Centre Avenue, Fort Collins, CO 80526
970-226-9474; Email: erin_muths@usgs.gov

Photo: Beyond Ypsilon Lake. Inset: *Bufo boreas* tadpoles in area – Cliff Knopf

This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards. This report is not for publication or for distribution outside the intended cooperators and the USGS.

Background

We surveyed Rocky Mountain National Park (ROMO) as part of the National Park Service's Inventory and Monitoring Program and in cooperation with the DOI Amphibian Research and Monitoring Initiative. The goal of this project was to document, with voucher specimens, 90% of the amphibian and reptile species occurring in ROMO. In 2001 we focused on the Kawuneeche Valley and in 2002 and 2003 we implemented a park wide survey using a statistically driven selection protocol that provided spatial coverage over the Park and multiple visits to selected sites. Earlier Park wide amphibian surveys were conducted between 1987 and 1994 (Corn et al. 1997) and in 2000 (Muths, unpub. data).

Hammerson (1999) lists 5 amphibians that occur in ROMO; tiger salamanders (*Ambystoma tigrinum*), chorus frogs (*Pseudacris triseriata*), wood frogs (*Rana sylvatica*), boreal (western) toads (*Bufo boreas*) and leopard frogs (*Rana pipiens*). Leopard frogs are listed as formerly occurring in ROMO (Hammerson 1999, Corn and Fogleman 1984) and have not been detected since 1974 (S. Corn, pers. com.). The wandering garter snake (*Thamnophis elegans*) is the only species of reptile reported for the Park.

Earlier surveys are detailed elsewhere (Corn et. al. 1997, reports to ROMO). This report details the 2003 surveys which focused on amphibians. An overview of amphibian and reptile occurrence in Rocky Mountain National Park is provided in the 2002 report.

Methods

Site selection

The same site selection methods were used in 2003 as detailed in the 2002 report (Muths 2002). We selected drainages at random with replacement, meaning that all drainages selected last year were "returned to the pot" before selection. Only one drainage that was selected in 2003 was also selected in 2002 (Table 1).

As in 2002, 4 of the 8 selected drainages were to be visited 4 times on 2 survey trips and four of the 8 selected were to be visited 2 times during one survey trip. In

addition to the selected drainages, 4 sites selected and were to be visited 4 – 8 times each. Three sites in the latter category were chosen based on accessibility (Lily Lake, Glacier Basin and Hollowell Park) and 1 because we detected a single boreal toad there last June (Ypsilon Lake area). A final category included 4 sites that are already locations for long-term projects. These sites (Lost Lake, Kettle Tarn, Spruce Lake and Gaskil Pond) were visited up to 10 times during the season.

Surveys

On a single survey trip, every water body in the drainage was surveyed twice, either by 2 technicians independently or by 2 technicians working together at 2 different times. For example, in areas where the number of sites within a drainage was very large, the sites would be sampled by each technician independently (different starting points with a short amount of time in between search start time). In very large areas such as wet meadows or river valleys, (e.g. no discreet ponds, but one interconnected “site”) the area would be sampled simultaneously. For example one technician would start on each side of the area and work their way up the valley, swapping sides on the way back down the valley. Both of these protocols yielded 2 visits per survey trip. Sites identified on National Wetland Inventory (NWI) maps were given priority when time was limited. Early in the season, some sites only received 1 visit per survey trip.

We used visual encounter surveys (VES) (Heyer et al. 1994) throughout the project. We searched for all life stages of amphibians (egg, larva and adult) and for adult reptiles. Dip nets were used to sample areas with limited visibility, and likely shallows with emergent vegetation were examined meticulously for eggs and larvae. Wetland areas, boulders, rocky outcrops, and downed woody debris received special attention. Dense forests received less attention but likely habitat such as woodpiles or rocky debris was searched. Habitat characteristics were recorded for all surveys. For each captured animal, the mass was determined, snout-vent length (SVL) measured, and the animal released at the capture site or kept as a voucher specimen.

Proportion of Area Occupied (PAO)

We are assessing the PAO for each amphibian species known to be present in the park. PAO analysis, using program PRESENCE (*sensu* MacKenzie et al. 2002) is used to provide an estimate of the proportion of sites in an area that contain a particular

species. The advantage of PAO over more commonly used estimates of occupancy rates such as a simple naïve estimate (number of sites where species is sighted divided by the number of sites searched), is that PAO analysis accounts for imperfect detectability (MacKenzie et al. 2002) which is often the case with amphibians.

Voucher collection

Specimens were collected to provide vouchers for the NPS Inventory and Monitoring Program and as part of the Amphibian Research and Monitoring Initiative. Information collected on each voucher included; date and time of collection, location at capture (UTMs), weather conditions, species, snout-vent length (SVL), mass, sex, coloration, behavior, date of preservation, and collector's name. Euthanasia and preparation of voucher specimens followed standard protocol (Heyer et al. 1994 and National Wildlife Health Laboratory and ARMI standard operating procedures; see the following websites: http://www.nwhc.usgs.gov/research/amph_dc/sop_anesth.html, http://www.nwhc.usgs.gov/research/amph_dc/sop_restraint.html). Adult specimens are stored in 70% ETOH, and egg and larval specimens are stored in 10% formalin (Gotte and Reynolds 1997). Voucher specimens are housed at USGS-FORT, Fort Collins, CO until direction is received from the National Park Service on where the vouchers will be housed permanently.

Results

Surveys

We spent 62.4 person hours searching for amphibians and reptiles at 79 sites in 8 selected drainages (Fig. 1, Table 1). Travel time (one-way, by foot, from trailhead to site) ranged from 1-4 hrs. We also visited 4 easily accessible sites a total of 14 times (travel time, as above ranged from .1 to 2.5 hrs), spending 16.2 person hrs searching (Fig. 1). Forty-five ponds were surveyed 1-3 times in the Kawuneeche Valley. The surveys in the Kawuneeche Valley were targeting wood frogs but other amphibian species were noted (see Report II). These surveys yielded at least one adult boreal toad (*B. boreas*) at a site near Ypsilon Lake, numerous wood frogs and chorus frogs on the west side of the Park, garter snakes at Hollowell Park and garter snakes and tiger salamanders at Lily Lake (Table 2).

We monitored 3 populations of boreal toads (2 in the North fork drainage of the Big Thompson River and 1 at Spruce Lake, see Report II) and a population of wood frogs on the west side of the Park in conjunction with other projects.

We assessed proportion of area occupied (PAO, MacKenzie et al. 2002) for each amphibian species for results in 2002 and in 2003 using program MARK (White and Burnham 1995). These data should be used cautiously because they are preliminary and because of the high number of 0s in the data (negative data, e.g. no amphibian detections). More surveys during wetter years might yield a higher number of sites with positive data allowing successful application of the proportion of area occupied modeling procedure.

The following narratives describe the surveys of selected drainages and sites in 2003 (Table 1). For each drainage, 1 survey trip = 2 visits and 2 survey trips = 4 visits.

I. Selected drainages

Beaver Brook / Moraine Park (Cub Creek) (Drainage 27)

20-22, 28 May, Survey Trip 1

Began at the Fern Lake Trailhead and hiked to Old Forest Inn campsite. The Big Thompson River was too high and fast to wade so sites across the river were not surveyed. We surveyed 14 sites between the Mill Creek trail to Cub Lake trail and back down to Moraine Park. Three adult tiger salamanders (*Ambystoma tigrinum*) and 12 salamander eggs were detected. Seven adult western chorus frogs (*Pseudacris maculata*) spotted and 2 common garter snakes (*Thamnophis elegans*) were also seen. Weather was mostly fair with a few rain showers.

30-31 July, Survey Trip 2

Began at the Cub Lake trailhead and hiked to Cub Creek campsite. Surveyed the beaver ponds along the south side of Cub Lake trail in the evening (cool and clear after heavy rain). Surveyed Cub Lake the next morning. We surveyed 13 sites and found no amphibians but 13 garter snakes.

Chapin River (South Cache la Poudre River) (Drainage 2)

9-10 June, Survey Trip 1

Began at the Corral Creek trailhead and hiked to Hague Creek campsite. Hiked along the banks of the Poudre River during the first evening searching wet meadows with short shrubs up to the forest edge where we encountered deep snow. A cold rain stopped surveys and continued into the night. The next morning we followed an unnamed creek west from the Poudre River to a large meadow and the headwaters of the unnamed creek. After following the same creek down, we continued south along the Poudre. We surveyed 9 sites in this drainage. Late winter conditions (deep snow) persisted along the river and into higher elevations and we encountered afternoon thunderstorms. No detections of amphibians or reptiles.

22 July, Survey Trip 2

Began at the Corral Creek Trailhead and repeated the surveys from 9-10 June. No detections of amphibians or reptiles. The weather was dry.

Black Canyon Creek (Drainage 37)

16-17 June, Survey Trip 1

Parked at Twin Owls trailhead and followed the Black Canyon trail to McGregor campsite. We surveyed 1 site near the trail at campsite after an evening rainstorm. We continued up the creek to the Tilestone Flats area the next morning and surveyed 5 sites in the area until thunderstorm curtailed surveys. No amphibians or reptiles detected.

Hunter's Creek, North St. Vrain, Sandbeach Lake (Drainage 35 part I)

23-25 June, Survey Trip 1

Parked at Sandbeach Lake trailhead and hiked to Hunter's Creek campsite. Used one long day to follow Hunter's Creek up past tree-line and along the North Ridge to Keplinger Lake (which was frozen). We surveyed 7 sites and detected no amphibians. The next morning we experienced sleet, hail and strong winds. In the afternoon we surveyed 6 sites starting at Sandbeach Lake, following

Sandbeach Creek through beaver ponds, then cutting through thick woods to small isolated ponds and wet meadows back towards the campsite. No detections of amphibians or reptiles.

4-6 August, Survey Trip 2

Parked at Sandbeach Lake trailhead and hiked to Hunter's Creek campsite. We surveyed 9 sites but the trip was cut short due to technician injury (non-job related). No detections of amphibians or reptiles.

Copeland Moraine, Copeland Lake (Drainage 35 part II)

3-5 June, Survey Trip 1

Began at Sandbeach Lake trailhead and surveyed 3 sites on the Meeker-Sandbeach trail. We located 2 adult chorus frogs. It rained during our survey of Copeland Lake and we found no amphibians or reptiles. On day 3 we parked at the Fern Lake Trailhead and surveyed a large site along the St. Vrain River among thick willows and beaver ponds. We detected 4 adult chorus frogs.

19 August, Survey Trip 2

Surveyed along the St. Vrain River from forest edge on the west end of the willows and searched among several beaver ponds; one chorus frog was detected. Surveyed Copeland Lake and 3 sites along the Sandbeach-Meeker Trail. We detected no amphibians or reptiles at these sites.

Mid Forest Canyon (Gorge Lakes) (Drainage 20)

30 June-3 July, Survey Trip 1

Parked at Forest Canyon Overlook and hiked down directly to Forest Lake. Surveyed Forest Lake and 3 other sites then hiked to Little Rock campsite. Followed the creek up through the Gorge Lakes, which were all at least partially frozen except for Arrowhead Lake, which was completely open. Four sites were surveyed. The weather was warm and mostly clear. From the Little Rock campsite we headed NNW along the ridge-side to 2 large wet meadows and then

to another meadow along the Big Thompson River before hiking back up to Trail Ridge Road. The weather was hot and sunny. We surveyed a total of 11 sites and found no amphibians or reptiles.

Echo Creek / Mt. Wescott (East Meadow) (Drainage 11)

14-16 July, Survey Trips 1 and 2

Parked at East Inlet Trailhead by Grand Lake and hiked to East Meadow campsite. Surveyed meadows along the creek in the evening during light rain showers. The next day we followed Echo Creek and surveyed a large meadow on both sides of the creek. The following day we followed the ridgeline on the south edge of East Meadow to a series of wet meadows and lily ponds. Fourteen sites were surveyed, including one incidental (not shown on NWI map) site. We detected a total of 8 adult garter snakes and 4 adult chorus frogs.

Beaver Creek / Opposition Creek (Drainage 5)

16-17 July, Survey Trip 1

We surveyed 6 ponds to the west of the road at the Beaver Creek picnic area (0.5 miles from Timber Creek Campground). The weather was hot with thunderstorms in the early afternoon. No amphibians or reptiles were detected.

Willow Creek, Long Draw Reservoir (Drainage 3)

24 July, Survey Trip 1

Parked at the west end of Long Draw Reservoir to visit 1 small pond near the southwest end of the reservoir. Began at the east dam of the reservoir and surveyed a site from the dam along the river to Willow Creek. We followed the creek to an open wet meadow that split in several directions and continued to follow a small stream up the eastern meadow to a saddle that divided Willow Creek from the unnamed creek in Drainage 2. Weather was clear. We surveyed 6 sites and detected no amphibians or reptiles.

II. Sites

Lily Lake (including incidental Site 3731)

The lake is mostly sand and rocks with little emergent vegetation except for at the west shore, where there are sedges and grasses growing very thickly. Along the south shore of Lily lake was a temporary wet meadow that eventually drained into the lake. Surrounding the meadow were thick willows that had small streams feeding into the meadow.

19 May, Survey Trip 1

Adult Western Chorus frogs were detected aurally at the incidental site south of the lake. No detections of amphibians or reptiles around the lake. The weather was overcast and chilly, and occasionally snowed.

5 June, Survey Trip 2

2 Adult Tiger Salamanders were observed during a light rainstorm.

31 July, Survey Trip 3

4 adult and 1 juvenile garter snakes were observed. No other reptiles or amphibians were seen. The water was cloudy compared to earlier visits. The weather was overcast.

31 July, Survey Trip 4

3 adult Garter snakes were observed. No other reptiles or amphibians were seen. The weather was clearing but there were storms approaching.

Hollowell Park

From the Hollowell Parking lot off of the Bear Lake Road, either follow the southern trail until the first grouping of willows on the right hand side of the trail, then cross the creek into a series of small meadows between thick willows that lead from beaver ponds, streams and springs west; or follow the northern trail until it bends left, just before entering the forest's edge and cut into the willows on the left, head east and follow the creek to beaver ponds.

19 July, Survey Trip 1

Rain began as the survey began, then came and went throughout. We followed the winding meadows from several beaver ponds, making a large 'U'. We detected one adult garter snake.

22 July, Survey Trip 2

No amphibians or reptiles were detected.

1 August, Survey Trip 3

We surveyed at the west end and worked in a large 'S' to the east end. There were moderate winds early in the morning. We found no amphibians or reptiles.

Glacier Basin

At the entrance to the Glacier Basin Campground, follow the road to the right, and then take another right at a split in the road. After a curve, there is a small picnic area with limited parking near a trail to Sprague Lake. The trail on the right crosses a small creek that has an opened area from the forest on both sides of the trail.

17-July, Survey Trip 1

No detections.

22-July, Survey Trip 2

No detections.

1 August, Survey Trip 3

While surveying the area, a large group on horseback followed the trail and crossed the creek. We surveyed to the north first, following the creek up, and the meadows back. We followed the meadow southward past a small waterfall coming from the woods into the creek, and found a wet meadow just on the other

side of the trees then followed the creek back to the trail. The weather was hot and clear. We detected no amphibians or reptiles.

Ypsilon Lake Area

At the Lawn Lake trailhead, follow the trail until it splits, follow the Ypsilon Lake trail to Ypsilon Lake. At the lake, follow the shoreline to the east. At the lake outlet, follow the ridge until reaching a low point and cross over to the north. Cross a second creek east of Fay Lakes and continue north. There is a sharp ridge running north to south, follow it to the northern most point, where there are wet meadows near tree line. There will be a rocky ledge to the north. Two small ponds are about 100 meters apart from each other (see Report II for map and UTM coordinates).

20 June, Survey Trip 1

No detections of any amphibians or reptiles. The weather was hot with thunderstorms.

9 July, Survey Trip 2

Arrived to the site after noon and observed approximately 100 boreal toad tadpoles in the eastern most pond along the northern shore. One tadpole was captured and preserved to confirm identification and document presence of boreal toads at site. The weather was hot and clear.

21 July, Survey Trip 3

Hail and rain fell for about 30 minutes approximately an hour before the survey began. During the survey the weather was partly sunny. We found an adult boreal toad at 3:52 and boreal toad tadpoles (approximately 50) at 4:22. A non-lethal skin scraping was taken from the adult for analysis for chytrid fungus.

1 August, Survey Trip 4

We observed approximately 250 boreal toad tadpoles. Hind legs were present and toes could be distinguished. Two male boreal toads were captured. Skin scrapings were collected from both individuals for analysis. The weather was partly cloudy.

Vouchers

The only voucher collected this year was a single *Bufo boreas* tadpole from the Ypsilon Lake Area to confirm the identification of boreal toad breeding activity (Table 3). The specimen is currently housed at FORT.

PAO Analysis

Two models were assessed, a time dependent model such that detection probability varied by time (= time of visit) (Model 1); and a model where detection probability was held constant over time (Model 2). Proportion of area occupied is low for amphibians in the Park. In 2002 and 2003 PAO ranged from 2–18 sites out of 100. These estimates are based on the best model and are therefore specific to that model (Table 3). For all species, PAO estimates in both years were \geq the naïve estimate of proportion of area occupied where the naïve estimate is determined by number of sites where a species is sighted divided by the number of sites searched. In 2002, Model 1 was the best model for salamanders, chorus frogs and wood frogs; but Model 2 was better for boreal toads. In 2003, Model 2 (detection constant over time) performed better for all species, suggesting that the probability of detection didn't change over the course of this field season.

Discussion

Although the area surveyed in 2003 is small relative to the total area of ROMO, two years of this sampling regime has provided good spatial coverage of the entire park (15 different drainages, 1 drainage surveyed in both 2002 and 2003). The surveys that have occurred in the Park previously also provide data on species occurrence. We are confident that we have documented the amphibian species that occur in ROMO. Chorus frogs and tiger salamanders are found in numerous localities throughout the Park (Fig.

1). Wood frogs, a species that has been de-listed recently from the State of Colorado threatened species list, is found at numerous localities on the west side of the Park in the Kawuneeche Valley (Fig. 1). The boreal toad, an endangered species in the State of Colorado, and candidate for Federal listing, breeds at 3 known localities in 3 drainages, the north fork of the Big Thompson River (1 populations) Spruce Creek (1 population) and the Roaring River (several adults and tadpoles). We did not observe a breeding aggregation of boreal toads at the Roaring River site, but observed up to 3 individual toads, tadpoles and metamorphs. While we do not yet know the extent of this population, it is the only confirmed boreal toad breeding effort outside of the 3 known populations known previously in ROMO in the last 9 years.

Confidence in our documentation of reptile occurrence in the park, especially occasional or rare occurrences, is less robust. The only reptile detected in ROMO in 2002 ad 2003 was the garter snake. Smooth green snakes are listed as a question mark in the species occurrence list for ROMO (Hammerson 1999). This snake occurs in Colorado between 5,500 – 9,000'. Although there is appropriate habitat in the Park (shrubby vegetation along mountain and foothill streams and meadows adjacent to riparian areas), there are no records for Larimer or Weld Counties (Hammerson 1999) or documentation for the park. There have been a variety of other reptiles captured or reported anecdotally for the park including a Texas rat snake, (J. Connor, pers. com.) that was collected in the Moraine Park campground in 2001, and several unconfirmed reports of rattlesnakes, bullsnakes and an unknown species of lizard near Lumpy Ridge (J. Connor, pers. com.). Hammerson (1999) reports the elevational range of the western rattlesnake (*Crotalus viridis*) as 7,500 – 9,500' and suitable habitats, such as montane woodland, mountain shrubland and riparian zones exist in the Park. A rattlesnake was observed near the Dunraven trailhead in the Comanche Peaks Wilderness Area northeast of the Park in 2000 (E. Muths pers. obs.) and there are numerous recorded occurrences in Larimer County (Hammerson 1999). A box turtle was also collected in the Twin Sisters area (J. Detterline and J. Connor, pers. com.).

The effort expended compared to new species found (Fig. 2) suggests that we located the variety of species that were present during our surveys. Other factors, such as drought, may play a role in the low numbers of species detected in the last 2 years,

and visual encounter survey methods are not ideal for more secretive species such as the smooth green snake. However, previous data from more normal water years suggest that we have identified all resident species for both taxa, reptiles and amphibians.

A comparison of PAO data and effort between years 2002 and 2003 highlights the need for the inclusion of covariates in the data analysis for proportion of area occupied. While technicians in both years were trained before surveying, pacing of the surveys by different crews varied. Number of hours spent searching and the number of sites surveyed decreased from 2002 to 2003. One likely explanation for this is that sites were physically larger in 2003 than in 2002 due to a heavier snowpack. The 2003 crew focused primarily on NWI designated sites present on the map and less on incidental (and likely ephemeral) sites; the crew would skip incidental sites in an effort to survey all the NWI sites. There were also a number of trips this year where weather and snowpack precluded surveys. Another possible explanation is that the 2002 crew was including more of their travel time between sites in their survey time estimates (this is not necessarily wrong if they were surveying [= looking for amphibians] during this time). Variation in PAO between years may be the result of environmental changes or observer differences or it can reflect real expansion or contraction of amphibian populations in the park. These possibilities can be addressed by including these covariates in the PAO analysis. We are in the process of adding these covariates to our analyses.

Recommendations

Rocky Mountain National Park covers a large area and we were able to survey a very limited number of drainages. Similar surveys, using the same protocols would provide better coverage and more confidence in our results. Surveys during very wet years or “average” years will contribute to the dataset. Drought conditions likely influenced our surveys in 2002 and although 2003 seemed to be wetter, at least in the spring, the effects of the drought were still apparent.

This project is designed to 1) identify both amphibians and (cursorily) reptiles in the park and 2) provide data that allows an estimation of the proportion of area occupied

by different species of amphibians in ROMO for the areas surveyed and, because of the survey design, inference about the proportion of area occupied by species of amphibians park-wide.

There are several ways to improve these data depending on the goals of the park. The inclusion of more drainages in the surveys will increase confidence in the PAO results. The inclusion of more drainages translates into the availability of more person power and vehicle support so that more locations can be surveyed during the breeding season. This would be useful to the park because at present, these data offer a coarse grain view of where amphibians are. Management issues such as the construction of new trails or amenities or visitor access occur at a much finer scale.

Specific questions about particular populations such as the wood frogs in the Kawuneeche Valley, or the boreal toads on the east side of the park may be best addressed with more in depth studies using capture – recapture protocols detailed in our 2002 report.

Survey protocols focused on a random sampling of the entire park rather than specifically focusing on habitat. Because ROMO has a generally depauperate reptile fauna, it would be appropriate to focus some intensive surveys on certain habitat types and locations from which the anecdotal observations have been reported to try and document occurrence in the park. It is likely that at least some of these species are occasional visitors to the park and possible that some species may breed in the park. More intensive surveys at appropriate sites could confirm this.

Acknowledgments:

Thanks to the staff at ROMO, especially Barry Sweet who worked with us patiently on camping arrangements and Cherie Yost who assisted in locating volunteers; Andrea Moore, Rick Scherer, Clif Knopf, David Canter, and Scott Ratchesford for field work; David Canter for additional help after the field season, Terry Giles and Tammy Fancher – map work and site selection.

Literature cited:

- Corn, P.S. and J.C. Fogleman. 1984. Extinction of montane populations of the northern leopard frog (*Rana pipiens*) in Colorado. *Journal of Herpetology* 18: 147-152.
- Gotte, S.W. and R.P. Reynolds. 1997. Observations on the effects of alcohol versus formalin storage of amphibian larvae. Invited oral contribution presented at the 1997 meeting of the American Society of Ichthyologists and Herpetologists.
- Hammerson, G.A. 1999. Amphibians and reptiles in Colorado. 1999. University of Colorado Press, Boulder and Colorado Division of Wildlife.
- Heyer, W.R., M.A. Donnelly, R.W. McDiarmid, L.C. Hayek, and M.S. Foster. 1994. Measuring and monitoring biological diversity standard methods for amphibians. Smithsonian Institution Press, Washington, D.C.
- MacKenzie, D.I., J.D. Nichols, G.B. Lachman, S. Droege, J.A. Royle and C.A. Langtimm. 2002. Estimating site occupancy rates when detection probabilities are less than one. *Ecology* 83:2248-2255.

Fig. 1. Map of ROMO indicating 40 drainages available for surveys. The eight selected drainages are numbered in red; * = drainages that received 1 survey visit; ** = drainages that received 2 survey visits; sites that received 4 or more visits are in blue.

Fig. 2: Species detected versus effort (survey time in person hours) for drainage surveys and multiple visit surveys.

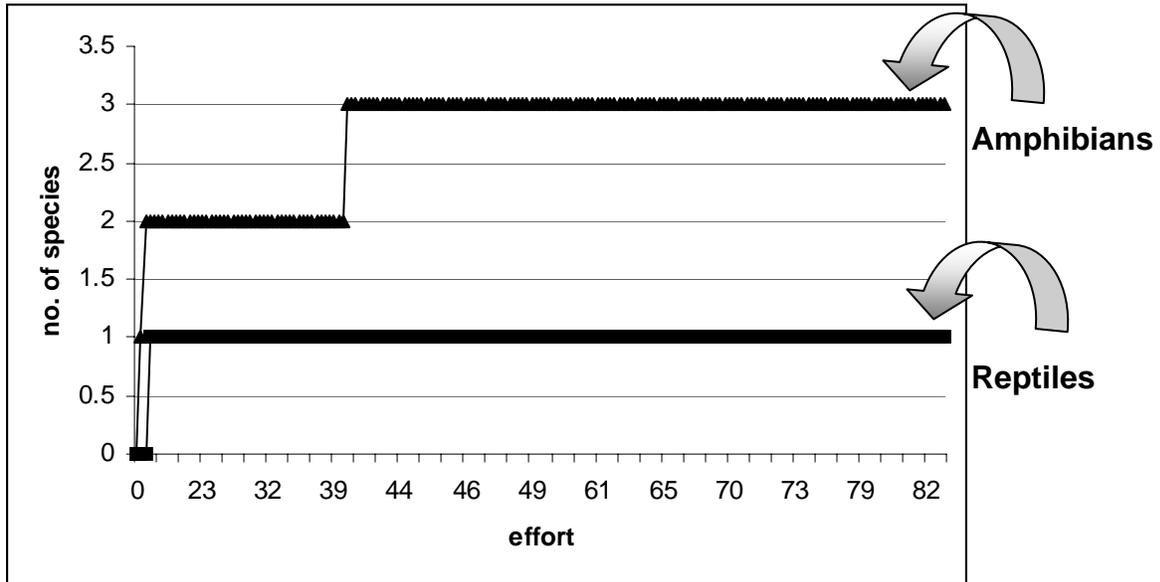


Table 1. Survey locations, date of surveys, effort 2003

drainage	location name	Easting	Northing	trail head used to enter area	planned survey trips	planned visits	actual survey trips	actual visits	# of discreet NWI sites in drainage (additional incidental sites)	# of sites surveyed	dates	effort (person hrs)	travel time (hr) trailhead to survey site
2	Chapin River			Corral Crk	2	4	2	3	26	12	9-10 Jun; 11 Jul; 23-24 Jul	12.5	3
11	Echo Crk / Mt. Wescott			East Inlet	2	4	1	3	28 (1)	12	14-16 Jul	6.4	
27	Beaver Brook / Moraine Park			Cub Lake	2	4	2	4	45	14	20-22 May; 28 May; 30-31 Jul	11.4	2
35	Hunter's Creek A (Hunter's Crk, N. St. Vrain, Keplinger Crk); Hunter's Crk B (Copeland Moraine, Copeland Lake)			Sandbeach Lake	2	4	2	3	23	16	A: 23-25 Jun; 4-6 Aug. B: 3-5 Jun; 19 Aug	20.8	4
5	Beaver Crk / Opposition Crk			Trail Ridge Rd	1	2	1	2	40	5	16-17 Jul	1.6	1
3	Willow Creek [§]			Corral Crk	1	2	1	2	27	5	23-24 Jul	4.7	3
20	Mid Forest Canyon			Forest Canyon Overlook (Trail Ridge Rd)	1	2	1	1	25	9	30 Jun - 3 Jul	3.4	4
37	Black Canyon Creek			Twin Owls	1	2	1	1	10	6	16-17 Jun	1.7	4
-	Hollowell Park	start: 448146 end: 427590	start: 4465373 end: 4465366	roadside	4	8	3	3	-	-	19 Jul; 22 Jul, 1 Aug	3.7	0.2
-	Glacier Basin			roadside	4	8	2	2	-	-	17 Jul, 1 Aug	1.8	0.2
-	Lily Lake			roadside	4	8	4	5	-	-	19 May; 3 Jun; 17 Jul; 31 Jul	7.2	0.1
-	Gaskil*			roadside	3	-	5	5	-	-	19 May; 20 May; 22 May; 26 May; 28 May	21.9	0.2
-	Kettle Tarn*			Dunraven	3	-	5	9	-	-	20 May; 28 May; 29 May; 9 Jun, 10 Jun, 16 Jun, 3 Jul, 25 Jul	20.9	1.8
-	Lost Lake*			Dunraven	3	-	3	5	-	-	17 Jun, 10 Jul, 11 Jul, 15 Jul	17.6	
-	Spruce Lake*			Fern Lake	3	-	7	-	-	-	11 Jun; 12 Jun; 18 Jun; 20 Jun; 26 Jun; 30 Jun; 7 Jul	37.3	2.0
	Ypsilon Lake Area			Lawn Lake	3	-	4	4	-	-	20 Jun; 9 Jul; 21 Jul; 1 Aug	5.4	2.5

*sites for other ongoing studies (see report II)

[§]drainage was also chosen for survey in 2002

Table 2: Raw data and animal observations:

site	visit no.	date	# of min. search	species	site	visit no.	date	# of min. search	species
452	1	23-Jul	22		1088	2	17-Jul	7	
452	2	24-Jul	42		1096	1	17-Jul	5	
463	3	24-Jul	7		1096	2	17-Jul	7	
463	4	24-Jul	6		1097	1	17-Jul	7	
463	1	23-Jul	24		1097	2	17-Jul	13	
463	2	23-Jul	26		1098	1	1-Jul	24	
510	1	24-Jul	18		1106	1	17-Jul	7	
510	2	24-Jul	20		1106	2	17-Jul	4	
520	1	10-Jun	130		1107	1	17-Jul	4	
520	2	25-Jul	11		1107	2	17-Jul	5	
533	1	10-Jun	48		1112	1	17-Jul	8	
533	2	25-Jul	20		1112	2	17-Jul	7	
546	1	24-Jul	60		1114	1	1-Jul	16	
546	2	24-Jul	38		1121	1	1-Jul	26	
567	1	24-Jul	42		1122	1	1-Jul	22	
567	2	24-Jul	28		1129	1	1-Jul	8	
615	1	24-Jul	15		1132	1	1-Jul	48	
615	2	24-Jul	9		1136	1	1-Jul	20	
627	2	23-Jul	40		1327	1	28-May	30	Psma, Amti
627	1	11-Jun	94		1332	1	13-Jun	94	Amti
627	4	23-Jul	48		1332	2	30-Jul	7	
634	1	24-Jul	12		1332	3	30-Jul	10	
634	2	24-Jul	12		1334	1	30-Jul	14	Thel
660	1	11-Jun	24		1335	1	30-Jul	8	Thel
660	2	25-Jul	9		1340	1	22-May	145	
674	1	23-Jul	24		1340	2	30-Jul	11	Thel
674	2	23-Jul	8		1341	1	13-Jun	38	Amti
674	3	23-Jul	5		1341	2	30-Jul	11	Thel
679	1	23-Jul	10		1343	1	30-Jul	9	
679	2	23-Jul	6		1344	1	30-Jul	8	
679	3	23-Jul	6		1344	2	30-Jul	3	
682	1	11-Jun	30		1345	1	30-Jul	14	Thel
682	2	25-Jul	15		1347	1	22-May	50	Psma, Amti, Thel
701	1	11-Jun	16		1347	2	30-Jul	38	Thel
701	2	25-Jul	8		1362	1	28-May	118	Psma, Thel
709	1	23-Jul	5		1362	2	31-Jul	27	
709	2	23-Jul	4		1364	1	31-Jul	7	
709	3	23-Jul	12		1364	2	31-Jul	6	
807	1	17-Jun	12		1366	1	31-Jul	6	
810	1	17-Jun	40		1366	2	31-Jul	9	
813	1	17-Jun	6		1367	1	31-Jul	11	
820	1	17-Jun	14		1367	2	31-Jul	8	
826	1	17-Jun	18		2044	1	5-Aug	13	
941	1	16-Jun	10		2044	2	5-Aug	7	
1042	1	2-Jul	14		2044	3	5-Aug	6	
1083	1	2-Jul	24		2050	1	24-Jun	12	
1088	1	17-Jul	6		2050	2	5-Aug	8	

Table 3: Raw data and animal observations (continued):

site	visit no.	date	# of min. search	species	site	visit no.	date	# of min. search	species
2050	3	5-Aug	6		2144	1	15-Jul	12	
2055	2	14-Jul	22		2158	1	2-Jun	22	
2055	3	16-Jul	9		2158	2	19-Aug	20	
2055	4	16-Jul	40		2165	1	2-Jun	12	
2055	1	14-Jul	10		2165	2	19-Aug	20	
2062	2	14-Jul	12		2167	1	25-Jun	62	
2062	3	16-Jul	8	Psma	2167	2	5-Aug	9	
2062	4	16-Jul	6		2167	3	6-Aug	7	
2062	1	14-Jul	3		2168	1	2-Jun	46	Psma
2067	2	14-Jul	4		2168	2	3-Jun	266	
2067	3	14-Jul	11		2168	3	21-Aug	20	
2067	1	14-Jul	3		2169	1	25-Jun	46	
2071	1	15-Jul	52	Thel	2169	2	5-Aug	7	
2071	2	15-Jul	48	Thel	2169	3	5-Aug	4	
2074	1	14-Jul	14	Thel	2176	1	5-Jun	38	
2074	2	14-Jul	5		2176	2	19-Aug	18	
2074	3	14-Aug	30	Thel	2183	1	3-Jun	180	Psma
2079	1	15-Jul	6	Thel	2183	2	19-Aug	101	Psma
2079	2	15-Jul	4		2193	1	25-Jun	26	
2079	3	16-Jul	7		2212	1	25-Jun	72	
2080	1	24-Jun	24		2230	1	25-Jun	16	
2080	2	5-Aug	11		2240	1	25-6	12	
2080	3	5-Aug	12		3731	1	19-May	70	Amti, Psma
2085	1	24-Jun	10		3732	4	16-Jul	30	
2085	2	5-Aug	4		3732	1	16-Jul	30	
2085	3	5-Aug	6		3732	2	16-Jul	6	
2087	1	24-Jun	38		3732	3	16-Jul	4	
2087	2	5-Aug	10		452A	1	24-Jul	22	
2087	3	5-Aug	40		627B	1	23-Jul	54	
2095	1	5-Aug	5		Glacier Basin	2	22-Jul	115	Psma
2095	2	5-Aug	5		Glacier Basin	3	1-Aug	46	
2095	3	5-Aug	4		Glacier Basin	1	17-Jul	95	
2096	1	16-Jul	4		Hollowell Park	2	22-Jul	188	
2096	2	16-Jul	6		Hollowell Park	1	19-Jul	33	
2101	1	16-Jul	8		Hollowell Park	3	1-Aug	71	
2101	2	16-Jul	6		Lily Lake	1	19-May	81	Amti
2101	3	16-Jul	4		Lily lake	2	5-Jun	98	Psma, Amti
2109	1	24-Jun	10		Lily lake	3	17-Jul	65	Amti, Thel
2109	2	5-Aug	4		Lily lake	4	31-Jul	62	Thel
2109	3	5-Aug	3		Lily Lake	5	31-Jul	66	Thel
2110	1	16-Jul	6		Ypsilon	1	20-Jun	136	
2110	2	16-Jul	3		Ypsilon	2	9-Jul	30	Bubo
2110	3	16-Jul	9		Ypsilon	3	21-Jul	96	Bubo
2111	2	16-Jul	7		Ypsilon	4	20-Aug	12	Bubo
2111	1	16-Jul	9						
2111	3	16-Jul	5						
2144	2	15-Jul	11						

Table 3: voucher collection ROMO.

Location	Species	Age class	Number	Date	UTM (NAD 27, zone 13)		error (m)
					easting	northing	
Ponds beyond Ypsilon Lake and Fay Lakes	<i>Bufo boreas</i>	tadpole	18269	9-7-03	444545	4477852	12

Table 4: PAO estimates for ARMI surveys in ROMO 2002 & 2003

Species	Psi	S.E.	Confidence interval		AICc	Delta AICc	AICc weight	Naïve estimate '02 / '03
			lower	upper				
<i>Ambystoma tigrinum</i>								0.033 / 0.068
**2002 P(t)	0.052	0.036	0.013	0.187	34.956	0	0.912	
2002 P(.)	0.035	0.03	0.006	0.173	39.641	4.68	0.877	
**2003 P(.)	0.124	0.059	0.047	0.292	72.695	0.000	0.999	
2003 P(t)	0.088	0.041	0.034	0.207	86.813	14.12	0.001	
<i>Pseudacris maculata</i>								0.047 / 0.114
**2002 P(t)	0.047	0.017	0.022	0.095	89.32	0	0.999	
2002 P(.)	0.067	0.026	0.030	0.140	108.996	19.68	0	
**2003 P(.)	0.180	0.064	0.085	0.340	98.255	0.000	0.999	
2003 P(t)	0.178	0.068	0.080	0.349	115.547	17.29	0	
<i>Rana sylvatica</i>								0.013 / 0.011
**2002 P(t)	0.039	0.052	0.003	0.379	38.185	0	0.949	
2002 P(.)	0.015	0.011	0.004	0.062	44.040	5.850	0.051	
**2003 P(.)	0.030	0.030	0	0.186	13.362	0	0.996	
2003 P(t)	0.030	0.030	0.004	0.186	24.193	10.83	0.004	
<i>Bufo boreas</i>								0.027* / 0.034
**2002 P(.)	0.04	0.02	0.1395	0.1043	82.109	0	0.999	
2002 P(t)	0.041	0.026	0.0118	0.1348	96.374	14.26	0.0008	
**2003 P(.)	0.037	0.021	0.012	0.108	46.818	0	0.997	
2003 P(t)	0.037	0.021	0.012	0.108	58.736	11.92	0.003	

P (t) = model 1: probability of detection varies by time (= visit)

P (.) = model 2: probability of detection is constant over visits

Naïve estimate = number of locations where animal was detected / number of locations searched (no. areas searched = 150 in 2002; 87 in 2003)

*based on 4 sites, only 3 of these sites are confirmed breeding sites

PSI = proportion of area occupied = PAO. Proportion based on 100.

** = best model, i.e. that which reflects the PAO most accurately based on the available data.